9.4.6 Groundwater

Numerous studies that provide information on groundwater conditions have been conducted in the LDW basin. Groundwater monitoring has been conducted at many facilities adjacent to and nearby the LDW (Map 9-17). Although most of those studies were conducted to assess conditions at specific facilities, they provide data that are useful in evaluating groundwater conditions in the greater LDW basin. Multiple seep and porewater sampling events have also been conducted in the LDW (see Maps 4-11 and 4-12, respectively). A review of existing groundwater data was conducted for 12 facilities identified as preliminary sites of interest by EPA and Ecology as part of the Phase 1 RI (Groundwater Pathway Assessment`, Appendix G in Windward 2003) (Map 9-17). This preliminary assessment evaluated the potential for chemicals in groundwater at these 12 facilities to reach sediment in the LDW through groundwater discharge based on data available at that time.

Table 9-15 provides a summary of groundwater information for the 12 facilities discussed in the Phase 1 RI assessment as well as numerous other facilities. Additional facilities were selected for inclusion in the table if they were shoreline properties associated with one of the 11 SCAs discussed in Appendix I,[1] or if they were identified by Ecology as being sites of interest for groundwater (Hiltner 2008). As part of their source control program, Ecology is also assessing groundwater at upland facilities associated with the SCAs, many of which are not included in Table 9-15. The SCAP and data gap reports present available groundwater information for all of the facilities associated with the SCAs.

Information in Table 9-15 was provided in the seep (Windward 2004) and porewater (Windward 2006) studies performed as part of the RI,[2] additional seep and porewater studies conducted as part of other investigations, documents prepared by Ecology as part of their LDW source control program, or in additional source documents provided by LDWG. Table 9-15 lists chemicals detected in groundwater, seeps, and porewater, when available, for each of the facilities. Table 9-15 also includes a list of chemicals that were detected above the SQS in surface sediment samples in the baseline dataset within the administrative boundary of the associated SCA or within the zone of potential groundwater discharge for the 12 facilities evaluated as part of

[1] Of the properties associated with the 11 SCAs discussed in Appendix I, only the shoreline properties were included in Table 9-15. Ecology is evaluating groundwater at several upland facilities associated with these 11 SCAs as part of their source control program. For groundwater information on upland facilities associated with the 11 SCAs that are not included in Table 9-15, see Ecology's SCAPs and data gaps reports.

[2] The RI seep survey was conducted over the entire LDW. In consultation with EPA and Ecology, some of the seeps observed were selected for sampling during the seep study. The porewater study was conducted near the Great Western International and Boeing Plant 2/Jorgensen Forge properties because these properties were identified as having the greatest potential to have VOC-contaminated porewater as a result of groundwater discharge.

the groundwater pathway assessment (Appendix G in Windward 2003).[3] Fate and transport and groundwater program information is also provided when available. Key references are listed for additional information.

[3] For facilities that were not included in the Phase 1 RI groundwater pathways assessment, the administrative SCA sediment boundaries provided by Ecology in February 2007 (Ecology 2007c) were used to produce the list of chemicals detected above the SQS. Those boundaries have been established only for administrative purposes and are based on the extent of the adjacent upland LDW sub-drainage basins of the SCAs; the boundaries are not intended to delineate potential sediment cleanup boundaries.

Table 9-15. Summary of available information for groundwater sites in the LDW

LDW RM	Facility	SCA	Chemicals Above SQS in the RI Baseline Surface Sediment Dataset within the Associated Sediment Area[a]	Chemicals Detected in Groundwater[b]	Chemicals Detected in Seeps	Chemicals Detected in Porewater	Groundwater Program Details and Fate and Transport Information, if Available	Sources of Additional Information
Shoreline Properties								
0.3 – 0.5 E	T-106 (northern portion of parcel, formerly referred to as T-106 W)	Duwamish/ Diagonal Way	cadmium, chromium, lead, mercury, silver, zinc, 2-methylnaphthalene, benzo(a)anthracene, benzo(a)pyrene, benzo(g,h,i)perylene, benzofluoranthenes, chrysene, dibenzo(a,h)anthracene, fluoranthene, indeno(1,2,3-cd)pyrene, naphthalene, phenanthrene, pyrene, total HPAHs, total LPAHs, BEHP, BBP, dimethyl phthalate, 1,2,4-trichlorobenzene, 1,2-dichlorobenzene, 1,4-dichlorobenzene, 2,4-dimethylphenol, 4-methylphenol, benzoic acid, benzyl alcohol, n-nitrosodiphenylamine, phenol, total PCBs, dioxins and furans[c,d]	arsenic , lead, toluene, petroleum-related compounds	No seep data were reported.	No porewater data were reported.	Groundwater sampling was conducted as part of an environmental site assessment in 2007; these investigations assessed UST locations and an area of historical cement kiln dust disposal.	Pinnacle Geosciences (2005; 2007)
0.3 – 0.5 E	T-106 (southern portion of parcel, formerly referred to as T-106 SW)	Duwamish/ Diagonal Way	cadmium, chromium, lead, mercury, silver, zinc, 2-methylnaphthalene, benzo(a)anthracene, benzo(a)pyrene, benzo(g,h,i)perylene, benzofluoranthenes, chrysene, dibenzo(a,h)anthracene, fluoranthene, indeno(1,2,3-cd)pyrene, naphthalene, phenanthrene, pyrene, total HPAHs, total LPAHs, BEHP, BBP, dimethyl phthalate, 1,2,4-trichlorobenzene, 1,2-dichlorobenzene, 1,4-dichlorobenzene, 2,4-dimethylphenol, 4-methylphenol, benzoic acid, benzyl alcohol, n-nitrosodiphenylamine, phenol, total PCBs, dioxins and furans[c,d]	arsenic, lead, petroleum hydrocarbons	No seep data were reported.	No porewater data were reported.	Groundwater sampling was conducted in the 1990s as part of LUST investigations and at a compressor area and a steam cleaning area.	Pinnacle Geosciences (2005)
0.5 – 0.7 E	T-108 (former Chyoda property)	Duwamish/ Diagonal Way	cadmium, chromium, lead, mercury, silver, zinc, 2-methylnaphthalene, benzo(a)anthracene, benzo(a)pyrene, benzo(g,h,i)perylene, benzofluoranthenes, chrysene, dibenzo(a,h)anthracene, fluoranthene, indeno(1,2,3-cd)pyrene, naphthalene, phenanthrene, pyrene, total HPAHs, total LPAHs, BEHP, BBP, dimethyl phthalate, 1,2,4-trichlorobenzene, 1,2-dichlorobenzene, 1,4-dichlorobenzene, 2,4-dimethylphenol, 4-methylphenol, benzoic acid, benzyl alcohol, n-nitrosodiphenylamine, phenol, total PCBs, dioxins and furans[c,d]	arsenic, cadmium, chromium, copper, lead, nickel, zinc, 1-methylnaphthalene, acenaphthene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzofluoranthenes, chrysene, fluoranthene, fluorene, naphthalene, phenanthrene, pyrene, total HPAHs, total LPAHs, PCBs, benzene, ethylbenzene, toluene, xylenes	No seep data were reported.	No porewater data were reported.	Numerous soil and groundwater investigations have been conducted at the facility over the past 20 years as part of site assessments and PCB disposal site investigations. A groundwater sampling program was implemented in 2006 and 2007 in accordance with an Ecology approved work plan. Based on the results, it was recommended that additional groundwater monitoring at the facility was not necessary.	Pacific Groundwater Group (2006; 2007); Windward (2003)
0.7 – 0.9 E	Federal Center South	Duwamish/ Diagonal Way	cadmium, chromium, lead, mercury, silver, zinc, 2-methylnaphthalene, benzo(a)anthracene, benzo(a)pyrene, benzo(g,h,i)perylene, benzofluoranthenes, chrysene, dibenzo(a,h)anthracene, fluoranthene, indeno(1,2,3-cd)pyrene, naphthalene, phenanthrene, pyrene, total HPAHs, total LPAHs, BEHP, BBP, dimethyl phthalate, 1,2,4-trichlorobenzene, 1,2-dichlorobenzene, 1,4-dichlorobenzene, 2,4-dimethylphenol, 4-methylphenol, benzoic acid, benzyl alcohol, n-nitrosodiphenylamine, phenol, total PCBs, dioxins and furans[c,d]	benzene, ethylbenzene, toluene, xylene, petroleum hydrocarbons	arsenic, cadmium, copper, lead, mercury, nickel, silver, zinc	No porewater data were reported.	Groundwater monitoring in 2000 identified a gasoline plume.	Ecology (2004), Windward (2004)
1.4 E	St. Gobain Containers (former St. Gobain Glass)	St. Gobain to Glacier Northwest[e]	zinc, chrysene, benzyl alcohol, phenol, total PCBs[c]	No groundwater data were reported.	No seep data were reported.	No porewater data were reported.	No groundwater monitoring program is in place.	
1.5 E	Longview Fibre Paper and Packaging	St. Gobain to Glacier Northwest[e]	zinc, chrysene, benzyl alcohol, phenol, total PCBs[c]	PAHs, SVOCs, petroleum hydrocarbons	No seep data were reported.	No porewater data were reported.	Groundwater monitoring took place in 2003 after remediation of a LUST; details were not available. It is unclear whether the groundwater monitoring is ongoing.	EDR (2006a)
1.6 E	BPB Gypsum/Old James Hardy Gypsum	St. Gobain to Glacier Northwest[e]	zinc, chrysene, benzyl alcohol, phenol, total PCBs[c]	No groundwater data were reported.	arsenic, cadmium, copper, lead, nickel, mercury, zinc, carbon disulfide, TPH (diesel)	No porewater data were reported.	No groundwater monitoring program is in place.	Windward (2004)

Table 9-15, cont. Summary of available information for groundwater sites in the LDW

1.75 E (northern parcel) and 1.9 E (southern parcel)	Duwamish Marine Center	Slip 2 to Slip 3[e]	total PCBs[c]	non-halogenated solvents, PCBs, petroleum hydrocarbons	arsenic, cadmium, copper, lead, mercury, nickel, silver, zinc	aluminum, arsenic, barium, cadmium, calcium, iron, lead, magnesium, manganese, potassium, sodium, vanadium, tributyltin as ion	Groundwater sampling conducted as part of site assessment related to CSCSL record; no record of formal groundwater monitoring program identified during assessment.	Cargill and Thomas (2007), EDR (2006b), Weston (1999)
2.1 E	SCS Refrigerated Services	Slip 3 to Seattle Boiler Works	arsenic, benzyl alcohol[c]	No groundwater data were reported.	No seep data were reported.	No porewater data were reported.	No fate and transport or groundwater program information was available.	
2.1 – 2.3 E	Glacier Marine Services	Slip 3 to Seattle Boiler Works	arsenic, benzyl alcohol[c]	No groundwater data were reported.	No seep data were reported.	aluminum, arsenic, barium, cadmium, calcium, copper, iron, lead, magnesium, manganese, potassium, silver, sodium, vanadium, zinc, dibutyltin as ion, tributyltin as ion	No fate and transport or groundwater program information was available.	Weston (1999)
2.1 – 2.3 E	Seattle Distribution Center	Slip 3 to Seattle Boiler Works	arsenic, benzyl alcohol[c]	No groundwater data were reported.	No seep data were reported.	No porewater data were reported.	No fate and transport or groundwater program information was available.	
2.2 – 2.25 E	Bunge Foods/Guimont Parcel (Dawn Food Products)	Slip 3 to Seattle Boiler Works, Seattle Boiler Works to Slip 4	arsenic, mercury, fluoranthene, total PCBs, benzyl alcohol[c]	No groundwater data were reported.	1,2-DCE, vinyl chloride[f]	No porewater data were reported.	No fate and transport or groundwater program information was available.	
2.3 E	Seattle Boiler Works	Seattle Boiler Works to Slip 4	mercury, fluoranthene, total PCBs[c]	No groundwater data were reported.	1,1-dichloroethane, 1,2-dichloroethane, 1,2-DCE, cis-1,2-DCE, trans-1,2-DCE, 1,2-dichloropropane, acetone, benzene, chloride, chlorobenzene, PCE, TCE, toluene, vinyl chloride, total xylenes[f]	1,1-dichloroethane, cis-1,2-DCE, trans-1,2-DCE, carbon disulfide, PCE, TCE, vinyl chloride[f]	No groundwater monitoring program is in place.	
2.4 E	Seattle Iron & Metals Corporation	Seattle Boiler Works to Slip 4	mercury, fluoranthene, total PCBs[c]	No groundwater data were reported.	1,1,1-trichloroethane, 1,1-dichloroethane, 1,2-dichloroethene, cis-1,2-DCE, 1,2,4-trimethylbenzene, acetone, PCE, TCE, vinyl chloride[f]	1,2-dichlorobenzene, 1,4-dichlorobenzene, 1,1-DCE, 1,1-dichloroethane, carbon disulfide, chlorobenzene, cis-1,2-dichloroethene, isopropylbenzene, toluene, trans-1,2-dichloroethene, vinyl chloride[f]	No groundwater monitoring program is in place.	
2.6 E	Puget Sound Truck Lines	Seattle Boiler Works to Slip 4	mercury, fluoranthene, total PCBs[c]	No groundwater data were reported.	No seep data were reported.	No porewater data were reported.	No groundwater monitoring program is in place.	
2.7 E	Seattle City Light	Seattle Boiler Works to Slip 4	mercury, fluoranthene, total PCBs[c]	No groundwater data were reported.	No seep data were reported.	No porewater data were reported.	No groundwater monitoring program is in place.	
2.8 E	Crowley Marine Services	Seattle Boiler Works to Slip 4, Slip 4	mercury, acenaphthene, benzo(a)anthracene, benzo(a)pyrene, benzofluoranthenes, benzo(g,h,i)perylene, chrysene, dibenzo(a,h)anthracene, fluoranthene, indeno(1,2,3-cd)pyrene, total HPAHs, BBP, BEHP, total PCBs[c]	arsenic, copper, 2-methylnaphthalene, acenaphthene, acenaphthylene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzofluoranthenes, chrysene, fluoranthene, fluorene, naphthalene, phenanthrene, pyrene BEHP, cis-1,2-DCE, acetone, dichloromethane	total PCBs	arsenic, barium, cadmium, lead, vanadium[g]	Groundwater sampling conducted in the 1980s and 1990s as part of site assessment; samples were collected from 12 wells and analyzed for metals, VOCs, SVOCs, TPH, chlorinated phenols, pesticides, and PCBs. There are plans for an additional groundwater investigation to be conducted on the facility.	SAIC (2006; 2007a; 2008a)
2.95 E	First South Properties	Slip 4	mercury, acenaphthene, benzo(a)anthracene, benzo(a)pyrene, benzofluoranthenes, benzo(g,h,i)perylene, chrysene, dibenzo(a,h)anthracene, fluoranthene, indeno(1,2,3-cd)pyrene, total HPAHs, BBP, BEHP, total PCBs[c]	arsenic, copper, zinc, TPH, 2-methylnaphthalene, acenaphthene, fluorene, phenanthrene, pyrene	mercury, copper	No porewater data were reported.	Groundwater sampling conducted in the 1980s and 1990s as part of site assessment and UST removals; samples were collected from 7 wells and analyzed for metals, VOCs, SVOCs, TPH, and PCBs. The site was granted an NFA in 1997 and groundwater monitoring was terminated in 1998. No record of an ongoing groundwater monitoring program was identified during this assessment.	Ecology (2006), SAIC (2007a), Windward (2004)

Table 9-15, cont. Summary of available information for groundwater sites in the LDW

2.9 – 3.6 E	Boeing Plant 2	Slip 4, Boeing Plant 2/ Jorgensen Forge	cadmium, chromium, copper, lead, mercury, silver, zinc, acenaphthene, benzo(a)anthracene, benzo(a)pyrene, benzofluoranthenes, benzo(g,h,i)perylene, chrysene, dibenzo(a,h)anthracene, dibenzofuran, fluoranthene, fluorene, indeno(1,2,3-cd)pyrene, phenanthrene, total HPAHs, total LPAHs, BBP, BEHP, phenol, total PCBs, dioxins and furans[c, d]	aluminum, antimony, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, iron, lead, magnesium, manganese, mercury, molybdenum, nickel, selenium, silver, thallium, vanadium, zinc, naphthalene, BEHP, di-n-buylphthalate, 2,4-dimethylphenol, 2-methylphenol, 4-chloro-3-methylphenol, 4-methylphenol, phenol, methyl isobutyl ketone, total PCBs, 1,1,1-trichloroethane, 1,1,2-trichloroethane, 1,1,2-trichlorotrifluoroethane, 1,1-DCE,1,1-dichloroethane, 1,2-dichloroethane, cis-1,2-DCE, trans-1,2-DCE, 1,2,4-trimethylbenzene, 1,3,5-trimethylbenzene, 4-isopropyltoluene,acetone, benzene, bromodichloromethane, carbon disulfide, carbon tetrachloride, chlorobenzene, chloroethane, chloroform, chloromethane, ethylbenzene, isopropylbenzene, n-butylbenzene, n-propylbenzene, PCE, sec-butylbenzene, TCE, tert-butylbenzene, toluene, trichlorofluoromethane, vinyl chloride, m,p-xylene, o-xylene, TPH (diesel, gasoline, and motor oil), 2-butanone, cyanide, methylene chloride	arsenic, chromium, copper, lead, mercury, selenium, zinc, fluoranthene, phenanthrene, total PCBs, cis-1,2-DCE, benzene, TCE, vinyl chloride	1,1-dichloroethene, cis-1,2-DCE, TCE, vinyl chloride[i]	Weston's (1998) mass loading analysis indicated no predicted accumulation in sediments for metals following bank removal. V PCBs were detected in seeps. The likely source of PCBs in seeps is sediment. VOC concentrations detected in porewater samples were less than toxicity thresholds for benthic invertebrates. Groundwater monitoring is on-going.	Ecology (2008), Ecology and Environment (2007b), Environmental Partners (2008), SAIC (2007b), Weston (1998), Windward (2003, 2006)
3.6 – 3.7 E	Jorgensen Forge	Boeing Plant 2/Jorgensen Forge	cadmium, chromium, copper, lead, mercury, silver, zinc, acenaphthene, benzo(a)anthracene, benzofluoranthenes, benzo(g,h,i)perylene, chrysene, dibenzo(a,h)anthracene, dibenzofuran, fluoranthene, fluorene, Indeno(1,2,3-cd)pyrene, phenanthrene, total HPAHs, total LPAHs, BBP, BEHP, phenol, total PCBs, dioxins and furans[c, d]	cadmium, benzene, ethylbenzene, toluene, vinyl chloride, xylenes, TPH (diesel)	arsenic, cadmium, copper, lead, mercury, nickel, silver, zinc	1,1-dichloroethene, cis-1,2-DCE, TCE, vinyl chloride[h]	No formal groundwater monitoring program is in place. Groundwater sampling was conducted as part of site investigations and/or tank removal.	Ecology and Environment (2007b), Environmental Partners (2008), Windward (2004)
3.7-3.8 E	Boeing Isaacson	Boeing Isaacson/ Central KCIA	arsenic, acenaphthene, benzo(a)anthracene, benzo(a)pyrene, benzofluoranthenes, benzo(g,h,i)perylene, chrysene, dibenzo(a,h)anthracene, dibenzofuran, fluoranthene, fluorene, indeno(1,2,3-cd)pyrene, phenanthrene, total HPAHs, total LPAHs, BEHP, BBP, benzoic acid total PCBs[e]	arsenic, cadmium, chromium, copper, lead, zinc	arsenic, cadmium, copper, lead, mercury, nickel, silver and zinc[i]	No porewater data were reported.	Several groundwater investigations have been conducted, including a hydrogeologic investigation in 2000. Apparent natural attenuation was noted based on a comparison of data from well pairs. Groundwater sampling was conducted in September 2007 and future sampling is planned.	Ecology (2008), SAIC (2008b), Windward (2003)
3.8 E	Boeing Thompson	Boeing Isaacson/ Central KCIA	arsenic, acenaphthene, benzo(a)anthracene, benzo(a)pyrene, benzofluoranthenes, benzo(g,h,i)perylene, chrysene, dibenzo(a,h)anthracene, dibenzofuran, fluoranthene, fluorene, indeno(1,2,3-cd)pyrene, phenanthrene, total HPAHs, total LPAHs, BEHP, BBP, benzoic acid, total PCBs[e]	arsenic	arsenic[i]	No porewater data were reported.	Groundwater sampling was conducted between 1988 and 2007. Additional groundwater sampling is planned.	Ecology (2008), SAIC (2008b), Windward (2003)
3.9 – 4.0 E	PACCAR (former Kenworth Truck Co.)	Slip 6	lead, BBP, total PCBs[e]	arsenic, barium, chromium, copper, nickel, selenium, zinc, benzo(g,h,i)perylene, chrysene, BEHP, benzyl alcohol, fluoranthene, total PCBs, 1,1,1-trichloroethane, 1,1,2-trichloroethane, 1,1-DCE,1,1-dichloroethane, 1,2-dichloroethane, cis-1,2-DCE, trans-1,2-DCE, acetone, benzene, chloroethane, chloroform, dichloromethane, methylene chloride, PCE, TCE, vinyl chloride, TPH (diesel, gasoline, and motor oil), glycols	arsenic, copper, lead	No porewater data were reported.	VOCs and TPH are likely attenuated and arsenic is in the range of background concentrations. Groundwater monitoring for VOCs occurred between 1986 and 2002. Two rounds of groundwater monitoring were completed in 2008.	Ecology and Environment (2008b), Windward (2003)
4.0-4.2 E	Former Rhone-Poulenc facility	Slip 6	mercury, acenaphthene, benzo(g,h,i)perylene, dibenzo(a,h)anthracene, fluoranthene, indeno(1,2,3-cd)pyrene, total HPAHs, BEHP, benzoic acid, phenol, total PCBs[e]	arsenic, beryllium, cadmium, chromium, copper, lead, mercury, selenium, silver, thallium, vanadium, zinc, benzo(a)pyrene, chrysene, BEHP, 2-methylphenol, 4-methylphenol, bis(2-chloroethyl)ether, PCP, 1,1-dichloroethane, acetone, benzene, dichloromethane, ethylbenzene, formaldehyde, toluene, xylenes	aluminum, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, lead, magnesium, mercury, nickel, vanadium, zinc, BEHP, formaldehyde	antimony, arsenic, chromium, barium, cadmium, copper, iron, lead, magnesium, manganese, mercury, vanadium, zinc, tributyltin, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, fluoranthene, pyrene, BEHP, diethylphthalate, 1,1-biphenyl, caprolactam	Groundwater investigations at the site began in 1985. As of 2007, over 10 years of quarterly groundwater monitoring has been conducted on the site. Toluene contamination in groundwater is still being investigated by EPA.	Ecology and Environment (2008b), EPA (2005), Rhone-Poulenc (1996), Weston (1999), Windward (2003)

Table 9-15, cont. Summary of available information for groundwater sites in the LDW

4.2 – 4.8 E	Boeing Developmental Center	Slip 6, Norfolk CSO/SD	lead, acenaphthene, total PCBs[c]	aluminum, arsenic, barium, calcium, cobalt, copper, iron, lead, magnesium, molybdenum, nickel, zinc, naphthalene, 1,1,1-trichloroethane, 1,1,2-trichloro-1,2,2-trifluoroethane, 1,1-dichloroethane, 1,2,4-trimethylbenzene, cis-1,2-DCE,1,3,5-trimethylbenzene, 2-hexanone, benzene, bromomethane, cis-1,3-dichloropropene, ethylbenzene, m,p-xylene, o-xylene, PCE, toluene, TCE, vinyl chloride, TPH (diesel, gasoline)	No seep data were reported.	No porewater data were reported.	Plumes of chlorinated solvents are reported to be locally contained and to not extend to the LDW. Natural attenuation expected for hydrocarbons and benzene (500 ft from LDW). Groundwater monitoring occurred as part of an Ecology NFA finding in 2001. Groundwater monitoring was discontinued in 2004.	Ecology and Environment (2007a, 2008b); Windward (2003)
4.6 E	Boeing Military Flight Center	Norfolk CSO/SD	fluoranthene, BBP, BEHP, 1,4-dichlorobenzene, total PCBs[c]	No groundwater data were reported.	No seep data were reported.	No porewater data were reported.	No groundwater monitoring program is in place.	
1.28 W	Alaskan Marine Lines	Glacier Bay	arsenic, copper, lead, mercury, zinc, acenaphthene, benzo (g,h,i) pyrene, chrysene, fluoranthene, indeno (1,2,3-cd) pyrene, phenanthrene, total HPAHs, BBP, BEHP, PCP, total PCBs, dioxin and furans[c, d]	1-methylnaphthylene, 2-methylnaphthalene, acenaphthene, acenaphthylene, anthracene, fluorene, naphthalene, phenanthrene, pyrene, benzene, xylenes (total), TPH (diesel, gasoline, motor oil)	No seep data were reported.	No porewater data were reported.	Groundwater sampling has been conducted as part of site assessment and UST investigations; no formal groundwater monitoring program is in place.	SAIC (2007d), Ecology (2007b)
1.35 W	Duwamish Shipyard	Glacier Bay	arsenic, copper, lead, mercury, zinc, acenaphthene, benzo (g,h,i) pyrene, chrysene, fluoranthene, indeno (1,2,3-cd) pyrene, phenanthrene, total HPAHs, BBP, BEHP, PCP, total PCBs, dioxin and furans[c, d]	arsenic, chromium, lead, benzo(a)pyrene, benzene, vinyl chloride	No seep data were reported.	No porewater data were reported.	No formal groundwater monitoring program is in place. Groundwater information collected from borings not completed as monitoring wells.	SAIC (2007d), Ecology (2007b)
1.45 W	Glacier NW (former Reichold Chemical)	Glacier Bay	arsenic, copper, lead, mercury, zinc, acenaphthene, benzo-(g,h,i) -pyrene, chrysene, fluoranthene, indeno (1,2,3-cd)-pyrene, phenanthrene, total HPAHs, BBP, BEHP, PCP, total PCBs, dioxin and furans[c, d]	arsenic, silver, naphthalene, 2,4,6-trichlorophenol, 2,4-dicholorpohenol, 2-chloropheonol, PCP	arsenic, copper, lead, mercury, silver, and zinc	No porewater data were reported.	Three wells installed in perched groundwater zone near former Reichhold waste pits; exact locations unknown. No formal groundwater monitoring program is in place.	SAIC (2007d), Ecology (2007b)
1.5 W	MRI Corporation	Glacier Bay	arsenic, copper, lead, mercury, zinc, acenaphthene, benzo (g,h,i) pyrene, chrysene, fluoranthene, indeno (1,2,3-cd) pyrene, phenanthrene, total HPAHs, BBP, BEHP, PCP, total PCBs, dioxin and furans[c, d]	No groundwater data were reported.	No seep data were reported.	No porewater data were reported.	No groundwater monitoring program is in place; however, the Port of Seattle is entering this site into Ecology's VCP program, and a new site investigation including groundwater will begin soon.	SAIC (2007d), Ecology (2007b)
2.2 W	Douglas Management Company	Trotsky Inlet	lead, mercury, zinc, BBP, BEHP, total PCBs, dioxins and furans[c, d]	No groundwater data were reported.	No seep data were reported.	No porewater data were reported.	No groundwater program is in place.	Ecology (2007a), SAIC (2007b; 2007c), Windward (2004)
2.2 W	Trotsky (former Northwest Cooperage, present day Industrial Container Services)	Trotsky Inlet	lead, mercury, zinc, BBP, BEHP, total PCBs, dioxins and furans[c, d]	antimony, arsenic, cadmium , chromium, copper, lead, mercury, nickel, silver, zinc, 2-methylnapthalene, acenaphthene, acenaphthylene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, dibenzofuran, fluoranthene, fluorene, ideno(1,2,3-cd)pyrene, naphthalene, phenanthrene, pyrene, BBP, BEHP, di-n-octyl phthalate,1,2,4-trichlorobenzene, 1,2-dichlorobenzene, 2,4-dimethylphenol, 2-methylphenol, 4-chloro-m-cresol, 4-methylphenol, benzoic acid, hexachlorobenzene, n-nitrosodiphenylamine, PCP, phenol, phenols (total), methyl isobutyl ketone, total PCBs, 2,4'-DDE, 2,4'-DDT, 4,4'-DDD, 4,4'-DDE, 4,4'-DDT, cis-chlordane, gamma-chlordane, lindane, 1,1-dichloroehtane, trans-1,2-dichloroethylene, acetone, benzene, dichloromethane, ethylbenzene, toluene, vinyl chloride, xylenes, TPH (diesel and gasoline), cyanide	arsenic, cadmium, chromium, copper, lead, mercury, nickel, silver, zinc, benzo(a)anthracene, fluoranthene, naphthalene, pyrene, diethylphthalate, dimethylphthalate, di-N-buytlphthalate, pentachlorophenol, 1,2-dichlorobenze, 1,3-dichlorobenzene, 1,4-dichlorobenzene, total PCBs, 2,4'-DDD, 4,4'-DDD, 4,4'-DDE, 4,4'-DDT, lindane, carbon disulfide, chlorobenzene, TPH (diesel)	No porewater data were reported.	Groundwater samples were collected as part of Phase I, II, and III soil and groundwater assessments; samples were collected from monitoring wells in 2007.	Ecology (2007a), SAIC (2007b; 2007c)
2.3 W	Boyer Towing properties (three parcels)	Trotsky Inlet	lead, mercury, zinc, BBP, BEHP, total PCBs, dioxins and furans[c, d]	No groundwater data were reported.	No seep data were reported.	No porewater data were reported.	No groundwater program is in place.	

Table 9-15, cont. Summary of available information for groundwater sites in the LDW

3.0 – 3.1 W (inland and shoreline portions)	Long Painting	none	PCBs, hexachlorobenzene[c]	arsenic, barium, chromium, lead, 1,1,1-trichloroethane, PCE	arsenic, cadmium, copper, lead, mercury, nickel, silver, zinc	tributyltin	Groundwater sampling has been conducted at the facility, however, no information was available regarding ongoing or future groundwater monitoring. No plume was identified on site, but groundwater data were insufficient. Metal groundwater COCs have not accumulated to concentrations above the SQS in adjacent sediments. The two VOC COCs were not detected in the single sediment sample analyzed for VOCs.	SEA (1998), Windward (2003; 2004)
3.4 – 3.5 W	South Park Marina	Terminal- 117	2-methylnaphthalene, acenaphthene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(g,h,i)perylene, benzofluoranthenes, chrysene, dibenzo(a,h)anthracene, dibenzofuran, fluoranthene, fluorene, indeno (1,2,3-cd)pyrene, phenanthrene, total HPAHs, total LPAHs, benzyl alcohol, phenol, total PCBs[c]	No groundwater data were reported.	No seep data were reported.	No porewater data were reported.	No groundwater program is in place.	
3.5 – 3.7 W	T-117	Terminal- 117	2-methylnaphthalene, acenaphthene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(g,h,i)perylene, benzofluoranthenes, chrysene, dibenzo(a,h)anthracene, dibenzofuran, fluoranthene, fluorene, indeno (1,2,3-cd)pyrene, phenanthrene, total HPAHs, total LPAHs, benzyl alcohol, phenol, total PCBs[c]	arsenic, cadmium, chromium, copper, lead, silver, zinc, 1-methylnaphthalene, acenaphthene, benzo(a)anthracene, total Benzofluoranthenes, chrysene, fluorene, naphthalene, total HPAHs, total LPAHs, BEHP, total PCBs, cis-1,2-dichloroethene, acetone, chlorobenzene, tetrachloroethene, trichloroethene, o-xylene, m,p-xylene, total xylenes, TPH (diesel, lube oil, and motor oil)	chromium, copper, zinc, bis(2-ethylhexyl) phthalate, total PCBs	No porewater data were reported.	Quarterly sampling was conducted in 1997-1998. Several groundwater investigations have been conducted from 1991 to 2006. Groundwater monitoring is ongoing.	Windward (2003) Windward et al. (2005, 2008)
3.67 – 3.91 W	Boeing South Park	Terminal- 117	2-methylnaphthalene, acenaphthene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(g,h,i)perylene, benzofluoranthenes, chrysene, dibenzo(a,h)anthracene, dibenzofuran, fluoranthene, fluorene, indeno (1,2,3-cd)pyrene, phenanthrene, total HPAHs, total LPAHs, benzyl alcohol, phenol, total PCBs[c]	No groundwater data were reported.	No seep data were reported.	No porewater data were reported.	No groundwater program is in place.	
Inland Properties								
0.7 – 0.9 E	Union Pacific Railroad Argo fueling site	Duwamish/ Diagonal Way	cadmium, chromium, lead, mercury, silver, zinc, 2-methylnaphthalene, benzo(a)anthracene, benzo(a)pyrene, benzo(g,h,i)perylene, benzofluoranthenes, chrysene, dibenzo(a,h)anthracene, fluoranthene, indeno(1,2,3-cd)pyrene, naphthalene, phenanthrene, pyrene, total HPAHs, total LPAHs, BEHP, BBP, dimethyl phthalate, 1,2,4-trichlorobenzene, 1,2-dichlorobenzene, 1,4-dichlorobenzene, 2,4-dimethylphenol, 4-methylphenol, benzoic acid, benzyl alcohol, n-nitrosodiphenylamine, phenol, total PCBs, dioxins and furans[c, d]	TPH (diesel)	No seep data were reported.	No porewater data were reported.	Groundwater monitoring wells were installed to monitor a diesel plume present beneath the facility. The plume migrates to the west. Groundwater remediation operations, including pumping and air sparging, were conducted between 2001 and 2004; over 38,000 gal. of diesel were recovered.	Ecology (2004), SAIC (2007c)
1.4 E	Philip Services Corp./ Burlington Environmental	none	mercury, zinc, chrysene, total PCBs, benzyl alcohol, phenol[e]	barium, cadmium, chromium, copper, lead, manganese, nickel, selenium, silver, vanadium, benzo(a)anthracene, benzofluoranthenes (total), benzo(g,h,i)perylene, chrysene, dibenzo(a,h)anthracene, indeno(1,2,3-cd)pyrene, benzoic acid, 1,1-DCE, 1,1-dichloroethane, 1,1,1-trichloroethane, 1,2-DCE, cis-1,2-DCE, trans-1,2-DCE, 1,2,4-trimethylbenzene, benzene, chlorobenzene, chloroethane, dichloromethane, ethylbenzene, PCE,TCE, toluene, vinyl chloride, xylenes, petroleum hydrocarbons, 2-butanone, ethane, methane	arsenic, cadmium, copper, lead, mercury, nickel, silver, zinc, TPH-diesel range, TPH	aluminum, arsenic, barium, lead, manganese, vanadium, tributyltin	Site-wide FS completed in 2006 concluded that chlorinated ethenes, 1,4-dioxane and possibly vinyl chloride, could reach the LDW at concentrations greater than the surface water protection criteria.[f] As of 2002, quarterly groundwater monitoring was ongoing. In 2004, a subsurface barrier wall and groundwater recovery system were installed on the facility. As of 2006, this system was still being monitored.	PSC (2001a; 2001b; 2002a; 2002b; 2002c), Geomatrix (2006)

Table 9-15, cont. Summary of available information for groundwater sites in the LDW

2.35 E	Great Western International (Fox Avenue Buildings)	Seattle Boiler Works to Slip 4	total PCBs[c]	aluminum, arsenic, barium, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, zinc, 2-chloronaphthalene, 2-methylnaphthalene, acenaphthene, anthracene, benzo(a)anthracene, chrysene, dibenzofuran, fluoranthene, fluorene, naphthalene, phenanthrene, pyrene, BEHP, diethylphthalate, dimethyl phthalate, di-n-butyl phthalate, 1,2-dichlorobenzene, 1,3-dichlorobenzene, 1,4-dichlorobenzene, 2,3,5-trichlorophenol, 2,4,5-trichlorophenol, 2,4-dichlorophenol, 2,4-dimethylphenol, 2-methylphenol, 4,6-dinitro-2-methylphenol, 4-chloro-3-methylphenol, 4-methylphenol, benzoic acid, benzyl acid, carbazole, isophorone, n-nitroso-di-n-propylamine, n-nitroso-di-n-propylamine, PCP, phenol, 1,1,1,2-trichloroethane, 1,1,1-trichloroethane, 1,1,2-trichloroethane, 1,1-dichloroethane, 1,2-dichloroethane, 1,1-DCE, 1,2-DCE, cis-1,2-dichloroethane, cis-1,2-DCE, trans-1,2-DCE, 1,2,4-trimethylbenzene, 1,2-dichloropropane, 1,3,5-trimethylbenzene, acetone, benzene, carbon disulfide, chloroform, DCE, ethane, ethene, ethylbenzene, iso-propyl benzene, iso-propyl toluene, n-butyl benzene, n-propyl benzene, PCE, sec-butyl benzene, styrene, TCE, tetrachloraphenols (total), toluene, trichlorofluoromethane, vinyl chloride, m,p- xylene, total xylenes, TPH (diesel and gasoline), 1,2-propanediol, 2-butanone, 2-propanol, 4-methyl-2-pentanone, diethylene glycol, ethylene glycol, methane, methanol, methylene chloride, sulfate	acenaphthene, total LPAH, total PAH, 1,1,1-trichloroethane, 1,1-DCE, 1,1-dichloroethane, 1,2,4-trimethylbenzene, 1,2-dichlorobenzene, 1,2-DCE (total), cis-1,2-DCE, trans-1,2-DCE, 1,2-dichloroethane, 1,2-dichloropropane, acetone, benzene, chlorobenzene, PCE, toluene, total xylenes, TCE, vinyl chloride, o-xylene	1,2-dichlorobenzene, 1,4-dichlorobenzene, 1,1-DCE, 1,1-dichloroethane, 1,2-dichloroethane, cis-1,2-DCE, trans-1,2-DCE, 1,2-dichloropropane, benzene, carbon disulfide, chlorobenzene, isopropylbenzene, PCE, TCE, toluene, vinyl chloride	Fate and transport analyses for VOCs indicated extensive degradation prior to discharge. In 2004, an underground injection control cleanup program was implemented at the site. As of 2006, the cleanup was still being conducted and its effectiveness was under evaluation. It was not specified whether these evaluations include a groundwater monitoring program. All VOC concentrations in porewater were less than toxicity thresholds for benthic invertebrates except for two cis-1,2-DCE concentrations in the high intertidal, which were greater than the no-effect threshold but less than the effect threshold.	SAIC (2008a), Terra Vac and Floyd & Snider (2000), Windward (2003), Windward (2006)
2.7 E	Georgetown Steam Plant	Slip 4	mercury, acenaphthene, benzo(a)anthracene, benzo(a)pyrene, benzofluoranthenes, benzo(g,h,i)perylene, chrysene, dibenzo(a,h)anthracene, fluoranthene, indeno(1,2,3-cd)pyrene, total HPAHs, BBP, BEHP, total PCBs[c]	PCBs, trichloroethylene	No seep data were reported.	No porewater data were reported.	Five groundwater monitoring wells were installed and quarterly groundwater monitoring (to continue for one year) was initiated in August 2006.	Ecology (2007c), SAIC (2007a)
2.7 – 3.35 E	North Boeing Field	Slip 4	mercury, acenaphthene, benzo(a)anthracene, benzo(a)pyrene, benzofluoranthenes, benzo(g,h,i)perylene, chrysene, dibenzo(a,h)anthracene, fluoranthene, indeno(1,2,3-cd)pyrene, total HPAHs, BBP, BEHP, total PCBs[c]	antimony, arsenic, beryllium, chromium, copper, lead, nickel, zinc, BEHP, total PCBs, cis-1,2-DCE, acetone, benzene, dichloromethane, ethylbenzene, PCE, TCE, toluene, vinyl chloride, total xylenes, TPH	No seep data were reported.	No porewater data were reported.	Groundwater monitoring has been conducted at several locations on NBF as part of previous site investigations. Ongoing semi-annual groundwater monitoring is occurring at two VOC locations and two TPH locations: nine wells are monitored for VOCs (cis-1,2-DCE, PCE, TCE, vinyl chloride), and six wells are monitored for TPH and BTEX.	SAIC (2007e)
3.6 W	South Park Landfill	none	acenaphthene, anthracene, benzo(a)anthracene, chrysene, dibenzofuran, fluoranthene, fluorene, indeno(1,2,3-cd)pyrene, phenanthrene, total HPAHs, total LPAHs, BBP, BEHP, benzyl alcohol, benzoic acid, PCBs, hexachlorobenzene[c]	aluminum, arsenic, barium, calcium, copper, iron, magnesium, manganese, potassium, selenium, cis-1,2-DCE, chlorobenzene, and vinyl chloride	arsenic, cadmium, copper, lead, mercury, nickel, silver, zinc	No porewater data were reported.	Vinyl chloride not expected to discharge at concentrations of concern because of relatively low concentrations and distance to LDW. Several rounds of groundwater monitoring have been conducted since 1997 and additional monitoring will likely be conducted in the future as part of a planned RI/FS at the site.	Windward (2003, 2004)
3.6 W	Basin Oil	Terminal- 117	2-methylnaphthalene, acenaphthene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(g,h,i)perylene, benzofluoranthenes, chrysene, dibenzo(a,h)anthracene, dibenzofuran, fluoranthene, fluorene, indeno (1,2,3-cd)pyrene, phenanthrene, total HPAHs, total LPAHs, benzyl alcohol, phenol, total PCBs[c]	aluminum, antimony, barium, beryllium, chromium, cobalt, copper, iron, lead, magnesium, manganese, mercury, nickel, selenium, silver, thallium, vanadium, zinc, PCBs, 1,1,1-trichloroethane, 1,1,2-trichloroethane, 1,1-DCE, 1,1-dichloroethane, cis-1,2-DCE, trans-1,2-DCE, acetone, chloroform, chloromethane, chloroform, DCE, PCE, TCE, cyanide	See the seep information provided for T-117. Basin Oil is located adjacent to T-117; groundwater from the two facilities likely discharges to the LDW in approximately the same zone.	No porewater data were reported.	Quarterly sampling was conducted in 1997-1998. Two single groundwater sampling events were conducted in 1991 and 1994.	Windward et al. (2003)

Table 9-15, cont. Summary of available information for groundwater sites in the LDW

4.1 W	Advance Electroplating	none	no exceedances within the zone of potential groundwater discharge[k]	aluminum, antimony, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, nickel, selenium, silver, thallium, vanadium, zinc, acetone, chloroform, chloromethane, PCE, TCE, (and their daughter products), cyanide	No seep data were reported.	arsenic, barium, copper, lead, manganese, vanadium	The site is a significant distance from LDW but may discharge to Hamm Creek first. Biodegradation and volatilization of VOCs is expected between the site and the LDW. No information was identified regarding an ongoing groundwater monitoring program; the most recent groundwater monitoring data are from February 1999.	Windward (2003)

Note: Information was provided in the groundwater pathway assessment (Appendix G in Windward 2003), the seep (Windward 2004) and porewater studies (Windward 2006) conducted for the RI, additional seep and porewater studies conducted as part of other investigations, documents prepared by Ecology as part of their LDW source control program, including SCAPs and data gap reports, and in additional source documents provided by LDWG members.

[a] Most of the chemical lists are based on SQS exceedances of RI baseline surface sediment data within the administrative SCA surface sediment boundaries established by Ecology in February 2007; however, some are based SQS exceedances within the zones of potential groundwater discharge estimated for facilities in the groundwater pathway assessment (Appendix G in Windward 2003). Footnotes c and k specify which lists were generated using the SCA administrative boundaries and which were generated using the zones of potential groundwater discharge.

[b] Includes chemicals detected in historical samples and more recent samples.

[d] SMS criteria do not exist for dioxins and furans. Dioxins and furans were included because they are a risk driver chemical with highly elevated concentrations (i.e., TEQ > 100 ng/kg dw) in surface sediment in the associated SCA.

[c] The list of chemicals is based on SQS exceedances of RI baseline surface sediment data within the administrative SCA surface sediment boundaries established by Ecology in February 2007. Chemical lists for facilities associated with more than one SCA include all chemicals detected above the SQS in both SCAs. The lists of chemicals detected above the SQS in surface sediment for T-108, Boeing Plant 2, Boeing Isaacson, and T-117 are based on exceedances within the administrative SCA surface sediment boundaries established by Ecology in February 2007, even though zones of potential groundwater discharge were established for these facilities in the groundwater pathway assessment (Appendix G in Windward 2003). The SCA boundaries were used because they covered approximately the same area as the zones of potential groundwater discharge (Appendix G in Windward 2003).

[e] The St. Gobain to Glacier Northwest and Slip 2 to Slip 3 SCAs were two of the 23 SCAs identified by Ecology, but they are not included among the 11 SCAs discussed in Appendix I. The rationale for the selection of the 11 SCAs is discussed in Appendix I. Facilities within these two SCAs are included in the table because they were identified by Ecology as facilities of interest for groundwater.

[f] The seep and porewater samples collected near the Bunge Foods/Guimont Parcel (Dawn Food Products) shoreline, the Seattle Iron and Metals shoreline , and the Seattle Boiler Works shoreline (see seep sampling locations between RM 2.2 and RM 2.5 East on Maps 4-11 and 9-17 and porewater sampling locations between RM 2.3 and RM 2.45 East on Map s4-12 and Map 9-17) were collected as part of investigations to characterize the Great Western International facility. These samples are also included in the information for the Great Western International (Fox Avenue Buildings) facility.

[g] Porewater sample was collected near the middle of Slip 4 (sample DR181 on 4-12).

[h] Porewater samples were collected near the Boeing Plant 2 and Jorgensen Forge property boundary (see sampling locations near RM 3.6 East on Map 4-12 and Map 9-17). Data from these samples are presented for both facilities.

[i] The seep sample in which arsenic, cadmium, copper, lead, mercury, nickel, silver and zinc were detected was collected along the Jorgensen Forge shoreline (sample SP-20 on Map 4-11) near the property boundary between Jorgensen Forge and Boeing Isaacson. Data for this seep sample are presented for both facilities.

[j] One seep sample was collected near the Boeing Isaacson and Boeing Thompson property boundary (sample Seep-1 on Map 4-11). Data from this sample are presented in the table for both facilities.

[k] The lists of chemicals detected above the SQS in surface sediment for these facilities are based on exceedances within the zone of potential groundwater discharge estimated for each facility in the groundwater pathway assessment (Appendix G in Windward 2003).

[l] Facility has not yet been associated with an SCA by Ecology.

[m] The final RI cleanup levels selected for Philip Services Corp for the water table, shallow, and intermediate groundwater were the minimum concentrations based on the following: calculated MTCA Method B groundwater cleanup levels based on an Asian Pacific Islander Exposure Scenario for the Consumption of Fish for the groundwater-to-surface water exposure pathway; AWQC based on Human Health Consumption of Organisms only (Section 304 of the federal CWA); ERA surface water screening levels protective of aquatic biota in surface water; AWQC freshwater and marine criteria maximum concentration, criteria continuous concentration, and organoleptic effects (Section 304 of the federal CWA); Washington State freshwater and marine acute and chronic effects criteria; and MTCA Method A cleanup levels (Geomatrix 2006).

Shading identifies the 12 facilities specifically discussed in Section 9.4.6.

AWQC – ambient water quality criteria
BBP – butyl benzyl phthalate
BEHP – bis(2-ethylhexyl) phthalate
COC – chemical of concern
CSCSL – Confirmed and Suspected Contaminated Sites List
CSO – combined sewer overflow
DCE – dichloroethene
dw – dry weight
FS – feasibility study
GWI – Great Western International
HPAH – high-molecular-weight polycyclic aromatic hydrocarbon
LDW – Lower Duwamish Waterway
LPAH – low-molecular-weight polycyclic aromatic hydrocarbon
LUST – leaking underground storage tank
NBF – North Boeing Field
NFA – no further action
PCB – polychlorinated biphenyl
PCE – tetrachloroethene
PCP –pentachlorophenol
RI – remedial investigation
RM – river mile
SAIC – Science Applications International Corporation
SCA – source control area
SD – storm drain
SQS – Sediment Quality Standards
SRI – supplemental remedial investigation
SVOC – semivolatile organic compound
T-108 – Terminal 108
T-117 – Terminal 117
TCE – trichloroethene
TPH – total petroleum hydrocarbon
UST – underground storage tank
VOC – volatile organic compound

It is important to note that additional reference documents containing groundwater data and other information exist for many of the facilities listed in Table 9-15; therefore, the summary may not be complete. The information in Table 9-15 is presented to provide a snap-shot of the state of groundwater investigations in the area of the LDW. Concentration ranges for selected chemicals detected in groundwater, seeps, and porewater are provided in Appendix I, as available, for many of the facilities listed in Table 9-15.[4] In-depth analyses have not been conducted as part of the RI for any of the facilities in Table 9-15; however, a preliminary assessment of 12 facilities was conducted as part of the groundwater pathway assessment in 2003 (Appendix G in Windward 2003), based on data available at the time. Groundwater pathway analysis is dependent on an assessment of a number of factors, including site-specific hydrogeology characteristics and chemical-specific fate and transport parameters. EPA and Ecology will continue to evaluate chemicals in groundwater and seeps as part of their continued source control efforts. Information on the hydrogeology of the LDW, including geology, physical properties, and groundwater systems, is included in Section 2.5.

Section 9.4.6.1 Phase 1 groundwater pathway assessment

The groundwater pathway assessment summarized information available through 2002 for 12 upland facilities identified by EPA and Ecology as preliminary sites of interest with respect to groundwater. These facilities were Advance Electroplating, Boeing Developmental Center, Boeing Isaacson, Boeing Plant 2, GWI, Long Painting, T-117 (former Malarkey Asphalt), PACCAR (former Kenworth Truck Co.), Philip Services/Burlington Environmental, the former Rhône-Poulenc facility, the South Park Landfill, and T-108 (former Chiyoda property) (Appendix G in Windward 2003). The locations of these facilities are shown on Map 9-17.

The following information was evaluated in the groundwater pathway assessment for each of the 12 facilities:

- Site operations and regulatory status
- Site-specific aquifer characteristics, groundwater flow direction, and rates of flow
- Chemicals identified as groundwater COCs (different criteria were used to select COCs for different facilities)
- COC concentrations in groundwater samples collected from monitoring wells located nearest to the LDW, as well as chemical contour or plume maps, when available
- COC concentrations in groundwater seeps or sediment in the LDW near potential areas of groundwater discharge
- Available fate and transport information

[4] Additional information is provided in Appendix I for facilities located within one of the 11 SCAs selected for summation.

Based on various screening criteria used at each of the facilities, COCs identified in groundwater included chlorinated solvents and their breakdown products, metals, BTEX compounds, TPH, PCBs, PAHs, and a few other organic compounds at a few facilities. The most common groundwater COCs were metals and chlorinated solvents, both of which were COCs at over half of the facilities. Groundwater COC lists for individual facilities may be updated by EPA or Ecology based on ongoing environmental investigations and source control work.

As part of the groundwater pathway assessment (Appendix G in Windward 2003), zones of potential groundwater discharge were estimated for each of the 12 facilities, and surface sediment data available at that time within that zone were reviewed to identify detections of the groundwater COCs above SMS criteria or DMMP guidelines.[5] The groundwater discharge zones were estimated based on the direction of groundwater flow from each facility to the LDW; additional investigations would be necessary to formally delineate the zone of potential groundwater discharge for each facility. Also, the concentrations of some of these chemicals (e.g., arsenic) may be of concern at concentrations below the SQS. Additional source analyses may be conducted prior to remediation for specific facilities as part of cleanup-related activities.

Limitations of the groundwater pathway assessment were associated with the type of data used for the analysis and uncertainties associated with the data. Uncertainties included: 1) all potential sources of groundwater contamination, such as the presence of uncharacterized fill material, may not have been addressed; 2) few groundwater samples were available for facilities on the west side of the LDW; and 3) SMS criteria or DMMP guidelines were unavailable for some chemicals. The preliminary results provided in the groundwater pathway assessment for each of the 12 facilities are summarized below and have been updated based on groundwater, seep, and porewater information collected or identified since completion of the assessment in 2003. Groundwater information is still being collected at several facilities in the LDW drainage basin and reviewed by EPA and Ecology. EPA and Ecology will make the final pathway determinations based on their continuing source control evaluations.

9.4.6.2 Seep study conducted for the LDW RI

In 2004, a seep study was conducted as part of the RI to evaluate whether seeps contributed significant chemical inputs to the LDW, to determine whether additional seeps should be sampled in the future as part of the RI or to provide source control information, and to determine whether additional surface sediment sampling was needed in seep areas (Windward 2004). A reconnaissance survey that resulted in the visual identification of 82 seep locations throughout the LDW was conducted; 18 of these locations were selected in consultation with EPA and Ecology for sample collection and chemical analysis. Seeps were selected for analysis based on the seep's

[5] Sediment information provided in Table 9-15 and discussed in this section is based on the RI baseline surface sediment dataset, which includes sediment data collected since the groundwater pathway assessment was completed.

proximity to potentially contaminated upland properties according to groundwater and information available at the time, seep flow, and any visual or olfactory indications (e.g., oily or colored seep water or intertidal sediment) that might suggest the potential presence of chemicals in the seep. Two of the 18 seeps selected for chemical analysis were not sampled because they were dry at the time of sampling. The locations of the 16 seeps sampled during the LDW seep study are shown on Map 4-11.

Seep sampling has also been conducted as part of several other investigations in the LDW. Information on these sampling events is provided in Table 4-10 and Section 4.1.3.1. The results of the seep sampling conducted for the RI and as part of other investigations are presented in multiple places throughout the RI: Table 9-15 (where chemicals detected in the seep samples are listed by facility); Table ___ (where seep data are compared to water quality criteria [Note: this table will be added in Section 4 and referred to in this section]); Section 4.2 (where seep results are described in further detail by chemical group); the following sections (where seep data associated with the 12 facilities included in the groundwater pathway assessment are discussed), and in Appendix I (where seep data associated with facilities located within the 11 SCAs selected for summarization are presented). EPA and Ecology may further evaluate seeps as part of their continuing source control efforts.

9.4.6.3 Porewater study conducted for the LDW RI

A porewater study was conducted as part of the RI in 2005 to determine whether VOCs in porewater posed a risk to benthic invertebrates (Windward 2006). Although VOCs rarely accumulate in sediment, organisms such as benthic invertebrates could be exposed to VOCs in areas downgradient from upland areas with high VOC concentrations in groundwater. Porewater samples were collected from areas adjacent to upland properties where VOCs had historically been detected in groundwater (Map 4-12). The GWI and Boeing Plant 2/Jorgensen Forge facilities were selected for the porewater investigation because existing data indicated that these areas had the greatest potential to have VOC-contaminated porewater as a result of groundwater discharge (i.e., maximum concentrations of some VOCs were at least an order of magnitude higher at these facilities than at any of the other 12 facilities evaluated[6] (Windward 2005)).

Porewater sampling has also been conducted as part of several other investigations in the LDW. Information on these sampling events is provided in Table 4-11 and Section 4.1.3.1. The results of the porewater sampling conducted for the RI and as part of other investigations are presented in multiple places throughout the RI: Table 9-15 (where chemicals detected in the porewater samples are listed by facility); Table ___ (where

[6] One possible exception was trichloroethene at Advance Electroplating, according to EPA's summary of other data collected from seven onsite wells by Hart Crowser in 2000 (Sanga 2002). The high concentrations of trichloroethene (200,000 µg/L) in one of the site wells suggest that non-aqueous phase liquid (NAPL) may be present beneath the site, although it was not detected in the 104 borings drilled to 13 ft by Ecology & Environment, or in the seven monitoring wells installed by Hart Crowser (Sanga 2002). The highest trichloroethene concentration documented in follow-up work was 2,600 µg/L.

porewater data are compared to water quality criteria [Note: this table will be added in Section 4 and referred to in this section]); Section 4.2 (where porewater results are described in further detail by chemical group); the following sections (where porewater data associated with the 12 facilities included in the groundwater pathway assessment are discussed), and in Appendix I (where porewater data associated with facilities located within the 11 SCAs selected for summarization are presented). Ecology and the SCWG may further evaluate chemicals in porewater as part of their continued source control efforts.(Windward 2005, 2006). 9.4.6.4 Groundwater, seep, and porewater study information for the 12 facilities included in the Phase 1 groundwater pathway assessment

This section presents a summary of groundwater, seep, and porewater information available for each of the 12 facilities evaluated in the groundwater pathway assessment (Appendix G in Windward 2003). Information collected or identified since completion of that assessment is also included.

Advance Electroplating

Advance Electroplating is located approximately 3,300 ft to the west of the LDW at RM 4.1 (Map 9-17) The facility was used for chrome plating operations from the mid-1960s to the early 1990s. A time-critical removal action (TCRA) under RCRA was conducted at the facility in the mid-1990s (Appendix G in Windward 2003). Chemicals identified as groundwater COCs that were evaluated in the groundwater pathway assessment included 10 metals (antimony, arsenic, cadmium, chromium, copper, lead, mercury, nickel, silver, and zinc) and 2 VOCs (tetrachloroethene and trichloroethene).[7]

The zone of potential groundwater discharge for Advance Electroplating was estimated to be between RM 4.1 and RM 4.2 (on the west side of the LDW) (Appendix G in Windward 2003); however, groundwater discharge zones for this facility have not been formally delineated. This zone was identified because it is the area where Hamm Creek discharges; it is probable that the Advance Electroplating facility's shallow groundwater discharges to a local ditch or other surface water drainage (e.g., Hamm Creek) before discharging to the LDW, given the relative elevation difference between the site and the LDW elevation, and the surface water drainage systems between the site and the LDW (Appendix G in Windward 2003). Additional groundwater investigations would be needed to formally delineate the groundwater discharge zone for this facility.

Water quality data are available for Hamm Creek (Herrera 2004, 2005) and were used in a pollutant loading analysis conducted for the Green-Duwamish watershed (Herrera 2007). The pollutant loading analysis included a calculation of loading values for Hamm Creek for total and dissolved copper, total and dissolved mercury, and total and dissolved zinc. This area was also included in the lateral loads analysis discussed in

[7] Chemicals were selected as groundwater COCs for Advance Electroplating in the groundwater pathway assessment if they were detected in groundwater and if SMS criteria or DMMP guidelines were available (Windward 2003).

Sections 3.2.5.1 and 9.4.4.6. Based on a review of the baseline surface sediment data collected from the zone of potential groundwater discharge, none of the potential groundwater COCs identified for the Advance Electroplating facility were detected above the SQS.[8]

Two porewater samples (unfiltered) were collected from the zone of potential groundwater discharge as part of an EPA SI (Weston 1999) (Map 9-17). Arsenic, barium, lead, manganese, and vanadium were detected in both porewater samples; copper was detected in one porewater sample. All of these chemicals were also detected in site groundwater (Table 9-15). VOCs were not analyzed in the porewater samples. No seep data from the zone of potential groundwater discharge were identified.

The groundwater quality within the deeper alluvium has not been evaluated. The clay layer identified above the alluvium by Ecology and Environment (1997) may have restricted downward COC migration. EPA's emergency action removed most of the contaminated soils from the facility in 1995 and 1996 (Ecology and Environment 1997). Note to EPA/Ecology: are there any status updates for this facility regarding groundwater?

Boeing Developmental Center

The BDC is located on the east side of the LDW between RM 4.2 and RM 4.8 (Map 9-17). One hundred and fifty seven solid waste management units (SWMUs) and five areas of concern (AOC) were identified and investigated at the facility under RCRA (Ecology and Environment 2007a). All but two of the SWMUs (SWMU-17, SWMU-20) were determined to not represent a threat to human health or the environment and were clean-closed in accordance with RCRA requirements (Appendix G in Windward 2003; Ecology and Environment 2007a). Of the SWMUs and AOCs that required further monitoring, three areas required additional groundwater investigation: SWMU-17, SWMU-20, and AOC 05. These areas are all located on the southern portion of the BDC.

Chemicals detected in groundwater at the BDC that were evaluated in the groundwater pathway assessment were arsenic, copper, lead, nickel, benzene, tetrachloroethene, and TPH.[9] The zone of potential groundwater discharge for the BDC was estimated to be the east side of the LDW between RM 4.4 and RM 4.8 (Appendix G in Windward 2003); however, groundwater discharge zones for this facility have not been formally delineated. Of the groundwater COCs for which SMS criteria exist, only lead was detected in surface sediments above the SQS (i.e., one CSL exceedance was detected near the southern end of the zone of potential groundwater discharge). No seep or porewater data have been collected from within the zone of potential groundwater

[8] All of the potential groundwater COC metals were analyzed for in all of the surface sediment samples collected from the estimated groundwater discharge zone; the two VOCs were only analyzed in one sample.

[9] Chemicals were selected as groundwater COCs for the BDC in the groundwater pathway assessment if they had been detected since 1998 in groundwater above MTCA Method B marine surface water cleanup levels (Appendix G in Windward 2003).

discharge for this facility.

Remedial actions at SWMU-17, SWMU-20, and AOC 05 have been conducted under RCRA corrective action authority. Pump and treat groundwater remediation was conducted at SWMU-20 from 1993 to 2001, and an electron donor injection was performed in 2004.[10] Groundwater monitoring conducted in May 2006 indicated that chemical concentrations at SWMU 20 have decreased since the initiation of groundwater treatment (Ecology and Environment 2007a). The groundwater monitoring data from SWMU-20 show that concentrations of chlorinated VOCs decreased downgradient of the former degreaser pit and that concentrations also decreased with depth so that the downgradient extent of chlorinated solvent detection was limited to within 200 ft of the original source area. The LDW is another 500 ft from the downgradient extent of the detected VOC plume (Appendix G in Windward 2003).

At AOC 05, an oxygen release compound (ORC) was injected into groundwater in 2002, and pilot testing of a bioremediation groundwater remediation system was initiated in 2007 (Ecology and Environment 2007a) to address TPH and benzene contamination.[11] Groundwater monitoring is ongoing at SWMU-17, SWMU-20, and AOC 05.

The data reviewed for the BDC as part of the groundwater pathways assessment indicated that the residual COC plumes are contained locally around the source areas. In the case of AOC 05, the UST source has been removed (Landau 2001), and the existing monitoring data indicate a very limited extent of residual hydrocarbon concentrations in groundwater (Appendix G in Windward 2003) Given the ongoing cleanup activities at SWMU-20 and AOC 05, and the distance from SWMU-17, SWMU-20, and AOC 05 to the LDW (over 700 ft), attenuation through biodegradation could be expected to reduce the residual hydrocarbon constituent concentrations before discharge to the LDW.

Additional information on the BDC is included in both the Slip 6 and Norfolk CSO/SD SCA summaries in Appendix I (Sections I.4.7 and I.4.8).

Boeing Isaacson

The Boeing Isaacson facility is located on the east side of the LDW between RM 3.7 and RM 3.8 (Map 9-17). Several remedial actions and environmental investigations have been conducted at the facility (Appendix G in Windward 2003) (also see Appendix I in this RI). Chemicals detected in Boeing Isaacson groundwater that were evaluated in the groundwater pathway assessment were arsenic, chromium, lead, and zinc.[12]

The zone of potential groundwater discharge for Boeing Isaacson was estimated to be between RM 3.7 and RM 3.9 on the east side of the LDW (Appendix G in Windward

[10] SWMU-20 is approximately 0.25 ac in size.

[11] Toluene, enthylbenzene, and xylene are being remediated at AOC 05 by ORC injection and the bioremediation system.

[12] Chemicals were selected as groundwater COCs for Boeing Isaacson in the groundwater pathway assessment if they were detected in the 1988 sampling event above either their freshwater or marine AWQC (Appendix G in Windward 2003).

2003); however, groundwater discharge zones for this facility have not been formally delineated. With the exception of arsenic, none of the chemicals identified in the groundwater pathway assessment were detected above the SQS in surface sediments in this area. Arsenic was detected above the CSL in two samples and above the SQS in one sample collected within the zone of potential groundwater discharge (see Map 4-14e and Appendix I, Section I.4.6).

One seep sample was collected in support of a request for a groundwater NFA determination at the Boeing Isaacson facility (ERM and Exponent 2000). Dissolved arsenic was detected in the sample. An additional seep location (SP-20) along the Jorgensen Forge shoreline near the Jorgensen Forge and Boeing Isaacson property boundary was sampled in 2004 (Windward 2004). Arsenic, cadmium, copper, lead, mercury, nickel, silver, and zinc were detected in both filtered and unfiltered samples collected from this seep location.

Additional sampling was conducted in 2006 and 2007 and samples were analyzed for total and dissolved arsenic (SAIC 2008b). Data from these sampling events are summarized in Appendix I (Section I.4.6).

. A comparison of arsenic concentrations in groundwater samples collected in the 1990s near the shoreline relative to samples collected from upgradient wells located slightly inland from the shoreline noted an apparent attenuation process occurring in groundwater at Boeing Isaacson (Appendix G in Windward 2003). These wells are screened within the same aquifer zone and indicated at least an order of magnitude reduction in arsenic concentrations within 100 ft of downgradient flow (Appendix G in Windward 2003). The potential for arsenic in groundwater to contaminate LDW sediments is being investigated at this site by Ecology (Ecology 2008). Groundwater sampling was conducted in 2007 and additional sampling is planned (Ecology 2008).

Boeing Plant 2

The Boeing Plant 2 facility is located on the east side of the LDW between approximately RM 2.9 and RM 3.6 (Map 9-17). Environmental investigations and corrective actions have been conducted at Boeing Plant 2 under RCRA since 1994 (see Appendix I, Section I.4.5). Groundwater data collected as part of several site investigations (Weston 1996, 1998, 2001a, 2001b, 2001c, 2002a; Weston Solutions 2002) were evaluated in the groundwater pathway assessment (Appendix G in Windward 2003). Chemicals that were identified as groundwater COCs in the groundwater pathway assessment were arsenic, cadmium, chromium, copper, lead, nickel, selenium, silver, thallium, zinc, PCBs, 1,1-dichloroethene, cis-1,2-dichloroethene, trichloroethene, and vinyl chloride.[13] Shoreline groundwater monitoring at Boeing Plant 2 is ongoing. Nine VOCs, thirteen metals, and PCBs were detected in samples from a recent semi-annual monitoring event (Environmental Partners 2008). Data gaps investigations have

[13] The chemicals selected in the groundwater pathway assessment as the groundwater COCs for the Boeing Plant 2 facility were those detected in boundary wells above Preliminary Media Cleanup Levels (PMCLs) (Appendix G in Windward 2003).

also recently been completed for upland areas at Boeing Plant 2. Recent data are presented in Appendix I.

Based on groundwater flow information, the zone of potential groundwater discharge for Boeing Plant 2 was estimated as extending from RM 2.8 to RM 3.6 on the east side of the LDW (Appendix G in Windward 2003); however, groundwater discharge zones for this facility have not been formally delineated. A review of the baseline surface sediment dataset (see Appendix I, Section I.4.5) indicates that of the groundwater COCs for which SMS criteria are available,[14] PCBs and all of the metals except for arsenic were detected in some areas at concentrations above the CSL in the zone of potential groundwater discharge.

In 1995, 21 seep samples (some filtered and some unfiltered) were collected from 18 locations along the Boeing Plant 2 and adjacent Jorgensen Forge facility shoreline as part of the Plant 2 RFI (Weston 1998) (see Map 4-11). Of the VOCs identified as groundwater COCs in the groundwater pathway assessment (Appendix G in Windward 2003), cis-1,2-dichloroethene, trichloroethene, vinyl chloride copper (total and dissolved), zinc (total), and total PCBs were detected in the seep samples..

In 2005, as part of the LDW RI (Windward 2006), 14 porewater samples were collected from locations adjacent to the Boeing Plant 2 and Jorgensen Forge facilities (see Map 4-12) and analyzed for VOCs. Four VOCs (vinyl chloride, 1,1-dichloroethene, cis-1,2-dichloroethene, and trichloroethene) were detected in porewater samples collected using peepers. At least one VOC was detected in samples collected from five of the eight locations at this site, with concentrations ranging from 0.2 µg/L (cis-1,2-dichloroethene and trichloroethene) to 13 µg/L (vinyl chloride).

A roughly 15-ac area of intertidal and subtidal sediments (referred to as the Duwamish Sediments Other Area [DSOA]) along the Plant 2 shoreline has been delineated for dredging and backfilling/capping remedial actions (Ecology and Environment 2007b) (see Appendix I, Section I.4.5). The approval and design of the dredging and backfilling/capping interim measure are currently in progress (Ecology and SAIC 2008). Further investigation is being planned to more fully characterize the depth of sediment contamination adjoining the navigation channel. As part of the planning for sediment remediation, Weston conducted a mass loading analysis and an equilibrium-partitioning model analysis to evaluate whether metals in groundwater had the potential to recontaminate sediment in the remediation area (Weston 2002b). The analyses indicated that after remediation, groundwater from the facility would not contaminate the sediment area at concentrations that would exceed the SQS within a reasonable time frame (i.e., hundreds of years).

Great Western International

GWI is located on the east side of the LDW approximately 400 ft to the northeast of the

[14] SMS criteria are not available for nickel, selenium, thallium, 1,1-dichloroethene, cis-1,2-dichloroethene, or vinyl chloride.

Myrtle Street embayment at RM 2.4 (Map 9-17). An RI/FS was initiated at the facility in 1991 to address soil and groundwater contamination associated with site operations (Appendix G in Windward 2003). In 2004, an underground injection control cleanup program was implemented. As of 2006, cleanup was still being conducted and its effectiveness was still under evaluation (Ecology and Environment 2008a). The groundwater pathway assessment used groundwater data obtained from the supplemental remedial investigation (SRI)/FS (Terra Vac and Floyd & Snider 2000). Chemicals that were identified as groundwater COCs were tetrachloroethene, trichloroethene, cis-1,2-dichloroethene, trans-1,2-dichloroethene, vinyl chloride, 1,1-dichloroethane, and methylene chloride.[15]

Based on groundwater flow information, the zone of potential groundwater discharge for GWI was estimated to be between RM 2.3 and RM 2.4 (Appendix G in Windward 2003); however, the groundwater discharge zone for this facility has not been formally delineated. One of the four surface sediment samples collected from within the zone of potential groundwater discharge was analyzed for VOCs, including all of the groundwater COCs, except methylene chloride. None of the groundwater COCs that were analyzed for in sediment were detected.

As part of the SRI/FS, 43 water samples were collected from sediment in the Myrtle Street embayment using absorbent screening modules called Gore-Sorbers® (Terra Vac and Floyd & Snider 2000). Two of the water samples contained detectable quantities of tetrachloroethene breakdown products. Seep samples were also collected in 1998 and 1999 as part of the SRI/FS (see Map 4-11); it is not known whether the seep samples were filtered or unfiltered. All of the groundwater COCs, with the exception of methylene chloride, were detected in the seep samples.

The key findings of the Myrtle Street embayment study (Terra Vac and Floyd & Snider 2000) were as follows:

- Groundwater discharge to the LDW at the Myrtle Street embayment was found to occur as discrete seep discharges in the intertidal zone. Generalized groundwater upwelling was not observed in the Myrtle Street embayment based on the Gore-Sorber study using VOCs as chemical markers.
- PCE and/or its degradation products were detected in Gore-Sorber modules placed in seep-face sediments along the eastern edge of the Myrtle Street embayment. This seep face was further delineated in a second sampling event and found to have a moderately long horizontal extent. The seeps were bounded in elevation (vertical extent) and found to occur between approximately -1 and -3 ft MLLW.

Porewater samples were collected from the zone of potential groundwater discharge for GWI as part of the RI (Windward 2006) (see Map 4-12). Piezometers were used to collect

[15] A chemical was identified in the SRI/FS as a COC for GWI if it was detected in monitoring wells located closest to the LDW above MTCA Method B cleanup levels.

porewater samples in deeper areas, and peepers (porous diffusion samplers) were used in shallower areas. The samples were analyzed for all of the groundwater COCs identified for GWI, with the exception of methylene chloride. None of the groundwater COCs were detected in porewater samples collected using piezometers, consistent with the results of the Gore-Sorber study and the conceptual site model (Windward 2005). In samples collected using peepers, all of the groundwater COCs analyzed were detected in two or more samples. Cis-1,2-dichloroethene and vinyl chloride were detected in every peeper sample collected from the zone of potential groundwater discharge for GWI. . The VOC results for porewater are discussed further in Section 4.2.10.

Based on groundwater, seep, Gore-Sorber®, and surface sediment data available at the time, the SRI/FS (Terra Vac and Floyd & Snider 2000) presented a fate and transport analysis of ethenes and ethanes. That analysis indicated that groundwater COCs were extensively degraded through reductive dechlorination.

Ecology is continuing to assess the GWI facility under MTCA and as part of their source control program for the LDW. Ecology and the GWI property owner (the facility is now called the Fox Avenue Building LLC site) are entering into an Agreed Order under MTCA for additional site investigation and cleanup (Ecology 2009). An interim cleanup action to address contaminant migration to the LDW is included in the Scope of Work under the Agreed Order.

Long Painting

The Long Painting facility is located on the west side of the LDW between approximately RM 3.0 and RM 3.1 (Map 9-17). A portion of the facility is adjacent to the LDW, and a portion is inland. Site investigations conducted in 1997 and 2000 (Kleinfelder 2000) included groundwater sampling (Appendix G in Windward 2003). Groundwater data collected in 2000 were used in the groundwater pathway assessment. Chemicals in groundwater that were identified as COCs were arsenic, chromium, lead, 1,1,1-trichloroethane, and tetrachloroethene.[16]

The zone of potential groundwater discharge for Long Painting was estimated to be between RM 2.9 and RM 3.1 on the southwest side of the LDW, based on groundwater flow information (Appendix G in Windward 2003); however, the groundwater discharge zone for this facility has not been formally delineated. None of the metals were detected above the SQS in the surface sediment samples collected from the zone of potential groundwater discharge in which they were analyzed (see Map 4-14d). The VOCs were not detected in the single sediment sample analyzed in this zone (Appendix G in Windward 2003).

One porewater sample was collected just outside the zone of potential groundwater

[16] The metals identified as COCs were selected in the groundwater pathway assessment for the Long Painting facility because they were detected in groundwater above MTCA Method A or B groundwater cleanup levels and in the monitoring well closest to the LDW (Appendix G in Windward 2003). The two VOCs were not detected above MTCA cleanup levels in any of the wells but were selected because it was not clear if the downgradient monitoring wells would capture a potential chlorinated solvent plume.

discharge for Long Painting; this sample was collected within the navigation channel at approximately RM 3.05 as part of the PSDDA sediment characterization of the LDW navigation channel (SEA 1998). None of the groundwater COCs for Long Painting were analyzed in the porewater sample.

One seep sample was collected from the zone of potential groundwater discharge as part of the RI (Windward 2004). Of the groundwater COCs for this facility, arsenic and lead were detected in the seep sample. Neither 1,1,1-trichloroethane nor tetrachloroethene was analyzed in this sample.

The groundwater pathway assessment concluded that there were insufficient groundwater data (i.e., representation of depth and location) to fully evaluate the potential for groundwater contamination on the Long Painting site. Note to EPA/Ecology: are there any status updates for this facility regarding groundwater?

T-117 (Former Malarkey Asphalt)

T-117 is the location of the former Malarkey Asphalt facility, which manufactured roofing asphalt and other petroleum-based products from 1937 to 1993. The site is located on the west side of the LDW, between approximately RM 3.5 and RM 3.7 (Map 9-17). Several environmental investigations and remedial actions have been conducted at the T-117 facility; and a non-time-critical removal action (NTCRA) for the remediation of soil, sediment, and adjacent streets is planned. Additional information on the background of and plans for the T-117 facility is included in the groundwater pathway assessment (Appendix G in Windward 2003) and Appendix I, Section I.4.11.

Groundwater data were collected from the site between 2003 and 2008 as part of the EE/CA for the NTCRA (Windward et al. 2008). Total PCBs, TPH, and chrysene were selected as the groundwater COCs for the T-117 facility in the EE/CA (Windward et al. 2008). As stated in the EE/CA, these groundwater COCs are expected to be addressed through the NTCRA removal of contaminated soil, which is the likely source of contamination to the groundwater (Windward et al. 2008).

The zone of potential groundwater discharge for the T-117/former Malarkey Asphalt facility was estimated to be the sediment area adjacent to the site, extending from RM 3.5 to RM 3.7, based on the proximity of the facility to this area and groundwater flow information (Appendix G in Windward 2003); however, the groundwater discharge zone for this facility has not been formally delineated. PCBs and several individual PAHs have been detected above the CSL in numerous sediment samples collected from the zone of potential groundwater discharge (see Appendix I, Section I.4.11).

In 2003, seep samples were collected from three locations within the zone of potential groundwater discharge for T-117 as part of the NTCRA investigation (Windward et al. 2005). Total PCBs were detected in one of the three seep samples. This seep was re-sampled because it was suspected that the detected PCB concentration of 0.94 J µg/L may have been associated with suspended solids in the water sample. The second

sample was centrifuged and analyzed, and PCBs were not detected at a reporting limit of 0.033 µg/L. No other groundwater COCs were detected in the seep samples. No porewater data have been collected.

Groundwater data have been collected at T-117 since 1991. Historical (pre-2003) groundwater conditions are summarized in the data gaps report (Windward et al. 2003). Groundwater monitoring has been conducted at T-117 periodically since 2003. Nine wells are currently located on the upland portion of the T-117 facility. Six wells are located along the shoreline (25 to 70 ft from the LDW), and three wells are upgradient (ENSR 2008). Recent groundwater data for T-117 are summarized in Appendix I (Section I.4.11).

PCBs have been detected in 11 out of 35 unfiltered groundwater samples collected between 2005 and 2008 in shoreline and upgradient wells at concentrations ranging from 0.010 to 2.0 µg/L (Windward et al. 2005; 2008). TPH was detected in 4 out of 19 samples ranging from 0.5 to 7.5 mg/L. Chrysene was detected in one sample at 0.50 µg/L.

In 2004, five shoreline wells were sampled. PCBs and chrysene were not detected. Samples collected from shoreline wells in 2005 were analyzed for PCBs and TPH. PCBs were detected in one shoreline well at a concentration of 0.040 µg/L and TPH was detected in another shoreline well at a concentration of 0.5 mg/L. In January 2006, the well with the PCB detection was re-sampled to confirm the 2005 result. PCBs were detected in the 2006 sample at 0.32 µg/L.

In August 2006, six shoreline wells were sampled. PCBs were detected in four of the shoreline wells, TPH was detected in one shoreline well at 0.94 mg/L, and no PAHs were detected.

In March 2008, groundwater samples were collected from the six shoreline wells and the three upgradient wells. PCBs were detected in four wells and TPH and PAHs were detected in two wells. TPH concentrations were 0.70 mg/L in a shoreline well and 7.5 mg/L in an upgradient well. Chrysene was detected in one well. Groundwater monitoring is still being conducted at T-117 as part of a quarterly groundwater monitoring investigation.

Although PCBs were detected in shoreline wells, PCBs have very low solubility and mobility in groundwater, except in the presence of a co-solvent such as petroleum fuel. Trace amounts of LNAPL (i.e., a sheen < 0.01 ft thick) were observed in two of the monitoring wells (MW-2 and MW-7) on one occasion during the 2005 tidal study. During the most recent groundwater monitoring event in February 2008 (ENSR 2008), no LNAPL was observed in any of the wells monitored. Concentrations of petroleum hydrocarbons (TPH-oil) were detected during quarterly groundwater sampling.

Groundwater in these wells is typically turbid, indicating the likelihood that low concentrations of PCBs present in the fine silts surrounding the well screens may be leaching into the wells during well purging. Thus, PCB detections in the groundwater

were likely the result of suspended soil particles (Windward et al. 2008).

Collectively, these data suggest that a majority of the PCBs detected in sediment near T-117 are most likely the result of past releases of surface water runoff, spillage from the upland area, or erosion of contaminated soil in the shoreline bank(Windward et al. 2008). Seep monitoring data collected to date indicate that seep discharges to the LDW do not appear to be a source to the sediment because chemicals detected in the seep samples (metals and BEHP) do not exceed the SQS in sediment and were not identified as site COCs (Windward et al. 2008). PCBs and chrysene were not detected in the seep samples (after centrifugation). However, PCBs have been detected in groundwater samples. A draft EE/CA (Windward et al. 2008) for the upland NTCRA is under review by Ecology. The goal of the upland cleanup is to remove most of the contamination from the upland site.

PACCAR (Former Kenworth Truck Co.)

The PACCAR facility (a former Kenworth Truck Co. manufacturing facility) is located on the east side of the LDW between RM 3.9 and RM 4.0 (Map 9-17). Environmental investigations and remedial activities, including groundwater extraction, were conducted at the facility in the 1990s in association with contamination from the former USTs located at the facility (see Appendix I, Section I.4.7). Groundwater data collected in the late 1990s and early 2000s (Kennedy/Jenks 2002; GeoEngineers and Kennedy/Jenks 1990; Kennedy/Jenks 1996, 1999) were evaluated in the groundwater pathway assessment (Appendix G in Windward 2003). Chemicals in groundwater that were identified as COCs were arsenic, barium, 1,1-dichloroethene, trichloroethene, tetrachloroethene, and vinyl chloride.[17]

The zone of potential groundwater discharge for the PACCAR/former Kenworth Truck Co. facility was estimated to be the sediment area adjacent to the site, extending from RM 3.9 to RM 4.0, based on the proximity of the facility to this area and groundwater flow information (Appendix G in Windward 2003); however, the groundwater discharge zone for this facility has not been formally delineated. Arsenic was not detected in surface sediments at concentrations greater than the SQS in the zone of potential groundwater discharge (see Map 4-14e). Barium was detected in three sediment samples collected from the zone of potential groundwater discharge; there are no SMS criteria or DMMP guidelines for barium. None of the VOCs identified as groundwater COCs have been analyzed in surface sediment samples collected from the zone of potential groundwater discharge.

Five seeps were sampled as part of a data gaps investigation at the PACCAR facility in 2002 (Ecology and Environment 2008b). Total arsenic was detected in one of the seep samples. Four seeps were sampled again in 2007; dissolved copper was detected

[17] The groundwater COCs identified in the groundwater pathway assessment for the PACCAR/former Kenworth Truck Co. facility were those chemicals that were detected above MTCA Method B or C cleanup levels or detected at concentrations greater than the cleanup and remediation levels at the adjacent Boeing Thompson facility (as reported in Kennedy/Jenks 2002; Appendix G in Windward 2003).

(Ecology and Environment 2008b). The data gaps report (Ecology and Environment 2008b) did not specify whether barium or VOCs were analyzed in the seep samples collected in 2002 and 2007.

The VOCs identified as COCs in site groundwater are associated with past releases from leaking USTs (Appendix G in Windward 2003). Tank removal and pump and treat remediation activities were conducted in this area. Groundwater monitoring data showed improvement in the groundwater quality during remediation (Appendix G in Windward 2003). In addition, an air sparging/soil vapor extraction (AS/SVE) system has been used at the facility since 2004 to treat a VOC plume in groundwater on the northwest portion of the facility (Ecology and Environment 2008b). The AS/SVE system consists of over 30 air sparging wells and 6 soil vapor extraction lines.

Site-wide groundwater monitoring was conducted in 2004 as part of the Phase II Data Gaps Investigation at the facility (Ecology and Environment 2008b). VOCs were detected in groundwater on the western portion of the facility and arsenic was detected above natural background. Additional groundwater monitoring was conducted in 2006 as part of a wet and dry season groundwater study. Vinyl chloride was identified by Ecology as a potential COC based on groundwater sampling results in nearshore wells; however, arsenic was not identified as a groundwater COC at the facility (Ecology and Environment 2008b).

Groundwater monitoring was also conducted in 2007 to assess the effectiveness of the AS/SVE system at treating the VOC plume. Wells to the north, south, and downgradient of the AS/SVE system (adjacent to the LDW) were sampled. Sampling confirmed that VOCs were below MTCA Method B surface water cleanup levels (Ecology and Environment 2008b). Recent groundwater data are summarized in Appendix I (Section I.4.7).

Ecology is still assessing groundwater at this facility as part of two Agreed Orders signed with PACCAR and the property owner (Merrill Creek Holdings LLC) and as part of their source control program for the LDW.

Philip Services/Burlington Environmental

The Philip Services/Burlington Environmental site is located approximately 4,300 ft to the east of the LDW at RM 1.4 (Map 9-17). An RFI was initiated in the late 1980s. Several investigations into groundwater conditions and potential sources of groundwater contamination were completed for this facility as part of the RFI and subsequent groundwater monitoring. Groundwater investigations conducted by Philip Services at offsite locations near the facility indicated there were likely additional sources of chlorinated solvents between the facility and the LDW.

Groundwater data evaluated as part of the groundwater pathway assessment (Appendix G in Windward 2003) were collected from wells thought to represent the western boundary of the groundwater plume originating from the Philip Services/Burlington Environmental facility. Groundwater COCs that were selected for

evaluation in the groundwater pathway assessment were benzoic acid, barium, cadmium, chromium, copper, lead, manganese, nickel, silver, 1,1,1-trichloroethane, 1,1-dichloroethane, chloroethane, 1,1-dichloroethene, cis-1,2-dichloroethene, tetrachloroethene, trichloroethene, vinyl chloride, benzene, toluene, ethylbenzene, and xylenes.[21]

The zone of potential groundwater discharge for Philip Services/Burlington Environmental was estimated to be the area between RM 1.1 and RM 1.8 on the east side of the LDW, based on groundwater flow information (Appendix G in Windward 2003); however, the groundwater discharge zone for this facility has not been formally delineated. None of the groundwater COCs that have SMS criteria were detected above the SQS in surface sediment samples collected from the zone of potential groundwater discharge (see Map 4-14b). None of the VOCs were detected in the three surface sediment samples analyzed from the zone of potential groundwater discharge.

Two seep samples have been collected from the zone of potential groundwater discharge (Windward 2004; Weston 1999) (Map 9-17). With the exception of barium and manganese, all of the groundwater COCs were analyzed in the seep samples. Cadmium, copper, and lead were detected in both seep samples, and nickel and silver were detected in one seep sample each.

One porewater sample was collected from within the zone of potential groundwater discharge; this sample was analyzed for metals and organometals. Of the metal groundwater COCs that were analyzed, only barium, lead, and manganese were detected in porewater.

In 2004, a subsurface barrier wall and a groundwater recovery system were installed. As of 2006, this system was still being monitored (Ecology and Environment 2008b).

(PSC 2001b). (PSC 2001) Fate and transport analyses conducted as part of the Feasibility Study for the PACCAR facility (Geomatrix 2006) indicated that COCs, including chlorinated ethenes, 1,4-dioxane and possibly vinyl chloride, could reach the LDW at concentrations greater than the surface water protection criteria.[22]

Former Rhône-Poulenc Facility

The former Rhône-Poulenc facility is located on the east side of the LDW between

[21] Chemicals were selected as groundwater COCs for Philip Services/Burlington Environmental if they were retained after the first step in the aquatic ERA conducted by Philip Services (PSC 2001b) and they were detected in monitoring wells closest to the LDW.

[22] The final RI cleanup levels selected for the water table, shallow, and intermediate groundwater were the minimum concentrations based on the following: calculated MTCA Method B groundwater cleanup levels based on an Asian Pacific Islander Exposure Scenario for the Consumption of Fish for the groundwater-to-surface water exposure pathway; AWQC based on Human Health Consumption of Organisms only (Section 304 of the federal CWA); ERA surface water screening levels protective of aquatic biota in surface water; AWQC freshwater and marine criteria maximum concentration, criteria continuous concentration, and organoleptic effects (Section 304 of the federal CWA); Washington State freshwater and marine acute and chronic effects criteria; and MTCA Method A cleanup levels (Geomatrix 2006).

RM 4.0 and RM 4.2 (Map 9-17). Multiple environmental investigations have been conducted at the site under RCRA since the 1990s (see Appendix I, Section I.4.7). Groundwater data evaluated in the groundwater pathway assessment were obtained from three separate reports: an RFI report (Rhône-Poulenc 1995), a sewer sediment technical document (Rhône-Poulenc 1996), and a groundwater monitoring report (GeoEngineers 2002). As of 2007, over 10 years of groundwater monitoring has been conducted at the site (Ecology and Environment 2008b). Groundwater COCs that were selected for evaluation in the groundwater pathway assessment were arsenic, chromium, copper, lead, mercury, vanadium, zinc, benzene, ethylbenzene, toluene, and xylenes.[23]

The zone of potential groundwater discharge for the former Rhône-Poulenc facility was estimated in the groundwater pathway assessment (Appendix G in Windward 2003) to be the sediment area adjacent to the site (RM 4.0 to RM 4.2 on the east side of the LDW) based on the proximity of the facility to the zone and groundwater flow information; however, the groundwater discharge zone for this facility has not been formally delineated. Of the chemicals with SMS criteria that were identified as groundwater COCs for this facility, only mercury has been detected above the SQS (i.e., one CSL exceedance) in surface sediment samples collected from the zone of potential groundwater discharge (Map 4-14e). One surface sediment sample collected within this zone was analyzed for VOCs; benzene, ethylbenzene, toluene, and xylenes were not detected in the sample (Appendix G in Windward 2003).

Several seep samples were collected from the zone of potential groundwater discharge for Rhône-Poulenc as part of an RFI (Rhône-Poulenc 1996) (Map 9-17). All of the groundwater COCs identified in the groundwater pathway assessment were analyzed in the seep samples and were detected in at least one sample.

Porewater samples have also been collected from the zone of potential groundwater discharge as part of the LDW site inspection (Weston 1999) and the Rhône-Poulenc sediment and porewater investigation (EPA 2005) (Map 9-17). All of the metals identified as groundwater COCs were analyzed in the porewater sample collected as part of the LDW site inspection; arsenic and lead were the only ones detected (Weston 1999). All of the chemicals identified as groundwater COCs were analyzed in the porewater samples collected as part of the Rhône-Poulenc sediment and porewater investigation (EPA 2005). Copper, mercury, and zinc were detected. Arsenic, chromium, lead, vanadium, benzene, ethylbenzene, toluene, and xylenes were not detected. Note to EPA/Ecology: Comment 270 stated that the 2004 Rhône-Poulenc porewater data should be added to this section; please note that these data are already discussed here (EPA 2005 citation).

EPA's LDW site inspection (Weston 1999) used sediment centrifugation to collect

[23] The groundwater COCs identified in the groundwater pathway assessment for the former Rhône-Poulenc facility were chemicals that were detected above action levels in groundwater (i.e., the lowest of the federal or state surface water quality standards for either fresh or marine water) in the monitoring wells closest to the LDW.

porewater samples. The Rhône-Poulenc investigation (EPA 2005) used a mini-piezometer and seepage meter to collect porewater samples. Barium, iron, and manganese were the only metals that were detected in samples from both studies. The concentrations of barium and iron detected in the LDW site inspection porewater sample were within the range of the barium and iron concentrations detected in the Rhône-Poulenc investigation porewater samples. However, the concentration of manganese detected in the LDW site inspection sample was nearly three times higher than the maximum manganese concentration detected in the Rhône-Poulenc investigation porewater samples.

Recent groundwater monitoring and geoprobe sampling in an area along the west-central shoreline detected toluene, arsenic, and copper. Recent groundwater data are summarized in Appendix I (Section I.4.7). Arsenic and copper concentrations in the sediment samples collected from the south west shoreline area were less than the SQS. EPA is currently investigating the toluene groundwater contamination in the southwest corner of the East Parcel (Ecology and Environment 2008b), in accordance with the Revised East Parcel Corrective Measures Implementation Work Plan (Geomatrix 2007).

South Park Landfill

The South Park Landfill is located approximately 2,000 ft to the southwest of the LDW at RM 2.6 (Map 9-17). The facility has been a MTCA site since the late 1980s, and an independent remedial investigation and quarterly groundwater monitoring program were implemented at the facility in 1997 (Appendix G in Windward 2003). Groundwater data collected in the late 1990s and early 2000s were evaluated in the groundwater pathway assessment. Vinyl chloride was the only groundwater COC identified in downgradient wells at the facility when the groundwater pathway assessment was conducted; therefore, it was the only chemical selected for evaluation in the assessment.

The zone of potential groundwater discharge for the South Park Landfill was not estimated in the groundwater pathway assessment, but could be between approximately RM 2.6 and RM 3.0, based on the fact that groundwater flows to the northeast from this site (Appendix G in Windward 2003); however, the groundwater discharge zone for this facility has not been formally delineated. One surface sediment sample collected between RM 2.6 and RM 3.0 on the west side of the LDW has been analyzed for vinyl chloride; vinyl chloride was not detected in the sample. One seep sample was collected from the west side of the LDW near RM 3.0 as part of the RI (Windward 2004a). Vinyl chloride was analyzed in this sample and was not detected. One porewater sample was collected within the navigation channel at approximately RM 2.65; the sample was not analyzed for vinyl chloride.

Long-term groundwater monitoring is ongoing at the South Park Landfill. During the past two semi-annual monitoring events, conducted in October 2008 and March 2009, vinyl chloride concentrations in groundwater were non-detect at the laboratory

practical quantitation limit of 0.2 µg/L at the down-gradient monitoring wells (citation to come). Preparations are underway for initiation of an RI/FS at the South Park Landfill (see Section 9.3.2.5 for additional information).

T-108 (former Chiyoda Property)

The T-108/former Chiyoda property is located on the east side of the LDW between RM 0.5 and RM 0.7 (Map 9-17). Numerous environmental investigations have been conducted at the facility (see Appendix I, Section I.4.1). Groundwater data evaluated in the groundwater pathway assessment were collected on the eastern portion of the facility in 1992 as part of a site assessment summary (AGI 1992). Chemicals that were considered to be groundwater COCs in the groundwater pathway assessment were arsenic, cadmium, chromium, copper, lead, nickel, zinc, total HPAHs, total LPAHs, and total PCBs.[25]

The zone of potential groundwater discharge for T-108 was estimated to be the sediment area adjacent to the site, from RM 0.4 to RM 0.7, based on the proximity of the facility and groundwater flow information (Appendix G in Windward 2003); however, the groundwater discharge zone for this facility has not been formally delineated. In general, groundwater at the site flows radially in all directions from a relative high near the center of the facility. This includes some relative flow to the north toward the Diagonal Ave S CSO/SD system; the potential interaction of groundwater with this drainage network is unknown.

Of the groundwater COCs, cadmium has been detected above the SQS in one surface sediment sample collected within the zone of potential groundwater discharge , total HPAHs have been detected above the SQS in two samples, and total PCBs have been detected above the CSL in two samples and above the SQS in several samples (see Map 4-14a). No seep or porewater samples have been collected from the zone of potential groundwater discharge .

The shallow groundwater samples from the T-108 site were collected primarily within dredge-fill material, above the native tideflat surface. PCBs were detected at low concentrations in samples collected before 1991, but not in any consistent pattern. PCBs were not detected in samples collected in 1991 and 1992. The 1991/1992 data did not detect PAHs above MTCA Method C levels.

Arsenic, cadmium, chromium, lead, and zinc were detected in a few monitoring wells at concentrations above the MTCA Method C cleanup criteria. Given the fine-grained nature of the onsite soils, and the old high flow groundwater sampling techniques used, it is suspected that some of the metals detected in the groundwater samples may be

[25] Chemicals selected as groundwater COCs for T-108 in the Phase I groundwater pathway assessment (Appendix G in Windward 2003) were those detected above MTCA Method A or C levels in any of the onsite wells that were also detected in wells closest to the LDW in 1992 (the most recent groundwater data available at the time of the assessment). In addition, copper, nickel, and zinc were selected because they exceeded federal AWQC, and PCBs were included as a conservative measure (Appendix G in Windward 2003).

associated with fine soil particles suspended in the water samples and subsequently dissolved in the acid extraction conducted for laboratory analysis (Appendix G in Windward 2003). Of these metals, none exceeded the SQS in the surface sediment in the zone of potential groundwater discharge.

Elevated concentrations of PCBs have been detected in sediments adjacent to the site; however, based on the groundwater data for the site and the known high attenuation of PCBs in groundwater, it is likely that a source other than groundwater migration was responsible for elevated PCBs in LDW sediment adjacent to this site (Appendix G in Windward 2003).

An additional groundwater monitoring program was conducted by the Port in 2006 and 2007 to further evaluate the T-108 groundwater pathway to LDW sediment (Pacific Groundwater Group 2006, 2007). Groundwater data are summarized in Appendix I (Section I.4.1). Chemicals detected in groundwater in the four rounds of sampling conducted as part of this program were arsenic (total and dissolved), chromium (total and dissolved), copper (total and dissolved), lead (total only), zinc (total and dissolved), and four individual PAHs.[26] Arsenic (total and dissolved) and lead (total only) were the only chemicals detected above MTCA Method A cleanup levels for groundwater. These exceedances were detected in samples collected during the first two rounds of sampling; arsenic and lead concentrations were below MTCA Method A cleanup levels in the third and fourth sampling rounds. The report concluded that the groundwater pathway for T-108 should be considered closed and that groundwater monitoring should be discontinued (Pacific Groundwater Group 2007). Upon review of the associated documentation, Ecology concurred with this recommendation and acknowledged that groundwater at T-108 was not a potential source of contamination to adjacent sediment in the LDW.

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